Surface Current Influence on Potential Vorticity Flux in Submesoscale Regime

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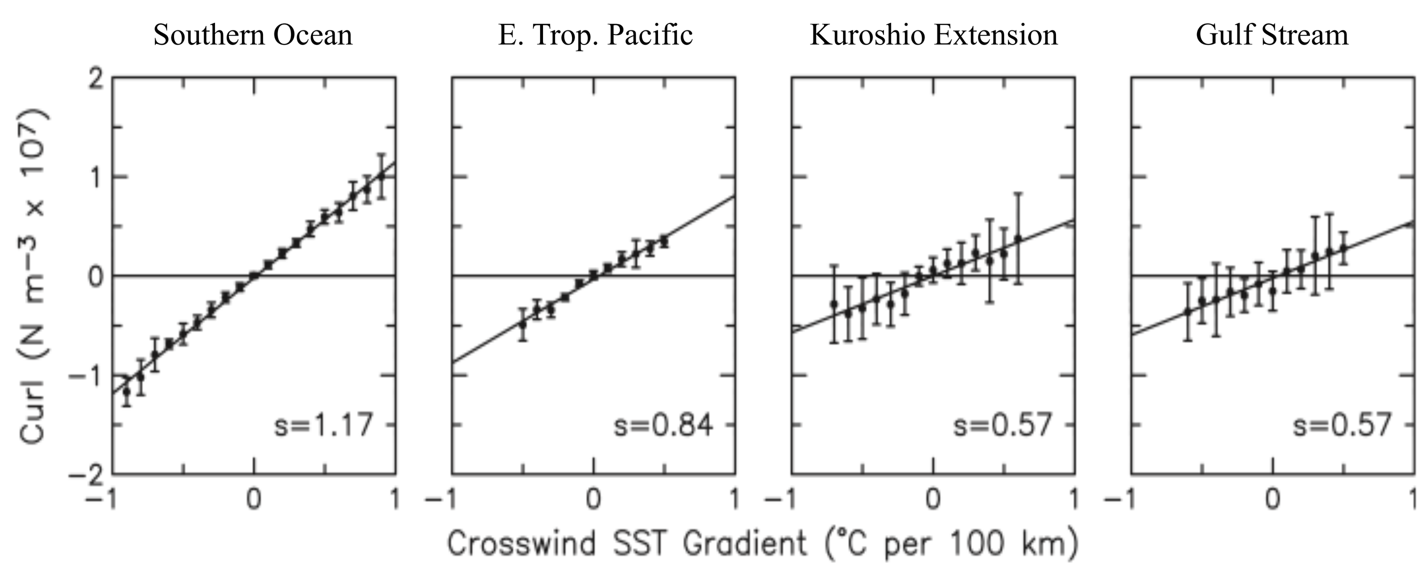
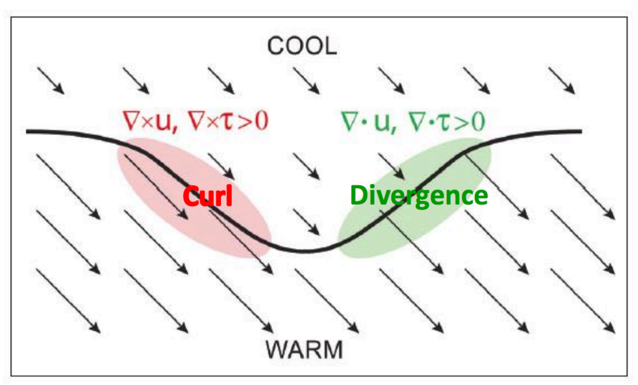
Introduction

- Positive linear relationship between wind stress curl and crosswind sea surface temperature (SST) gradient has been found by Chelton et al. (2004) on satellite observations (25-km resolution).



(Chelton et al. 2004)

- Stronger wind stress over warm water is argued to be the mechanism.



(Chelton et al. 2007)

- In the submesoscale regime, SST gradients are much stronger than those in the mesoscale and larger scale regimes. And surface current vorticity is significantly robust in submesoscale regime.

$$W_{total} = \frac{1}{\rho}\nabla\times\left(\frac{\vec{\tau}}{f+\zeta}\right)$$ (Stern, 1965)

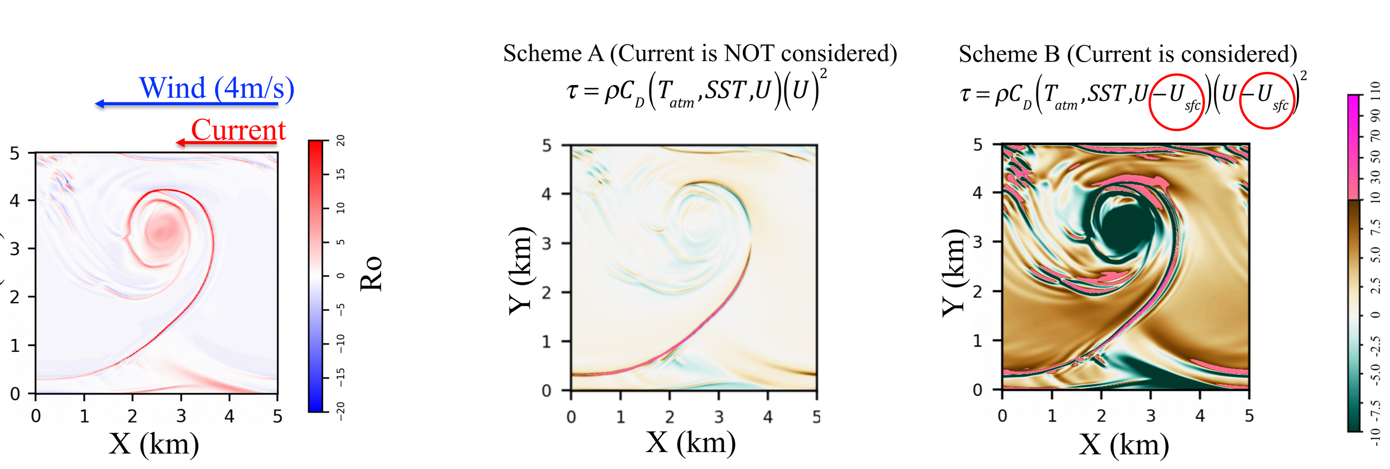
- Negative potential vorticity (PV) injection from the ocean surface is crucial for triggering instability in the upper ocean layer.

Goals

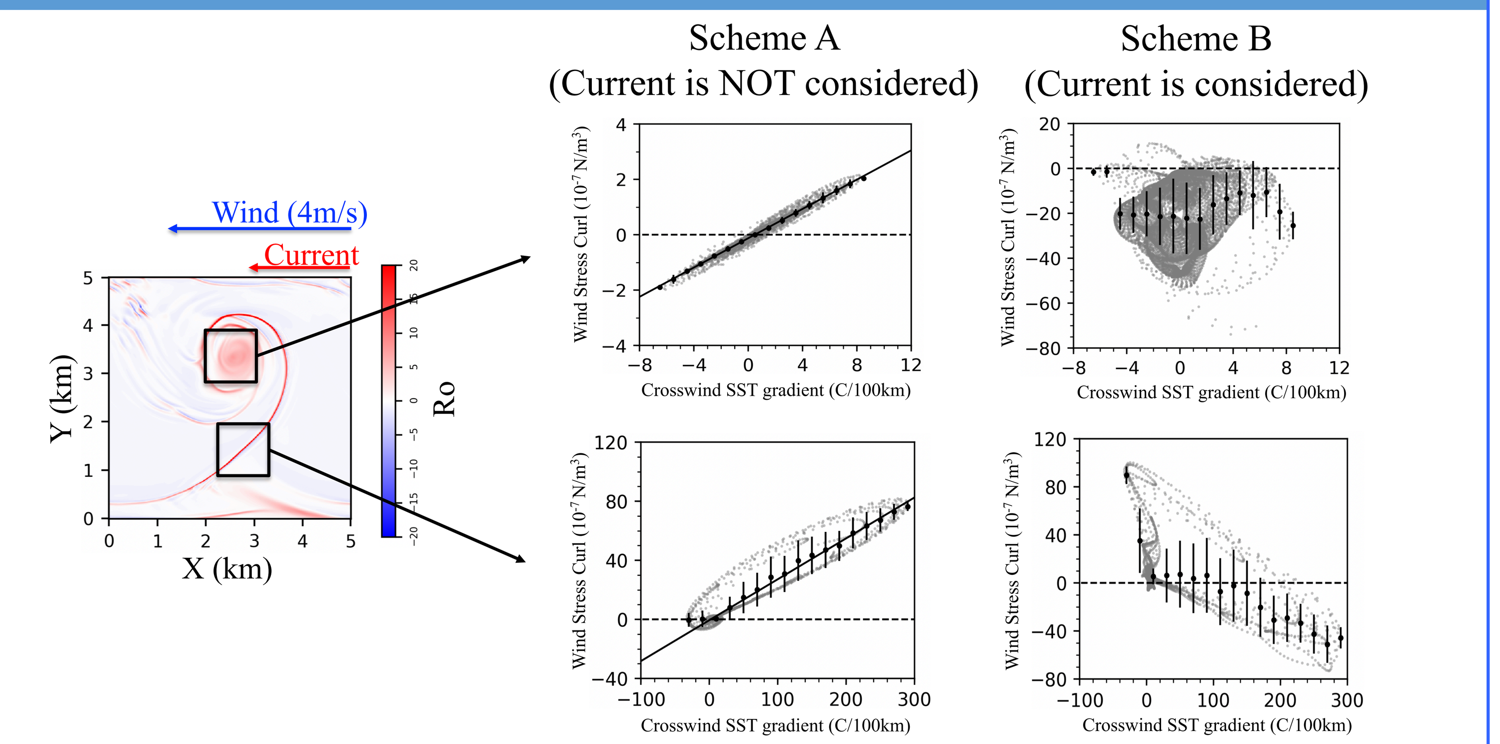
- Determine (quantitively) if wind stress field is significantly influenced by submesoscale surface features (SST gradient and current vorticity)?
- Assess (quantitively) the effect of including surface current in air-sea turbulent flux on the PV surface flux and vertical transports.

Model Setup

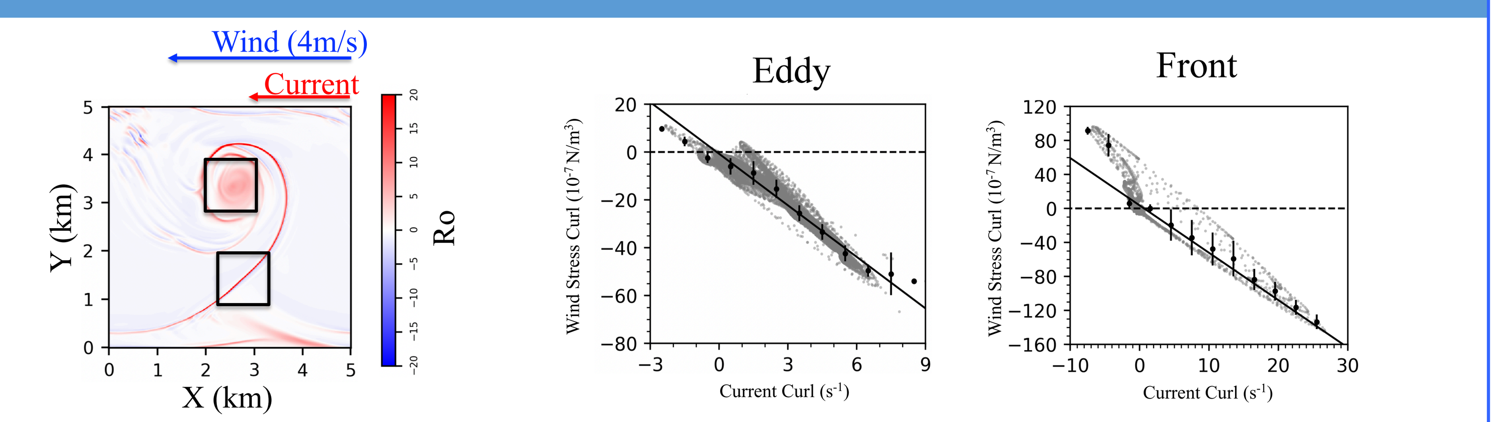
- Ocean: MITgcm; Atmospheric Boundary Layer: CheapAML
- Resolution: 10 m horizontal; 2 m vertical.



Wind Stress Curl & Crosswind SST Gradient (Scheme A & B)

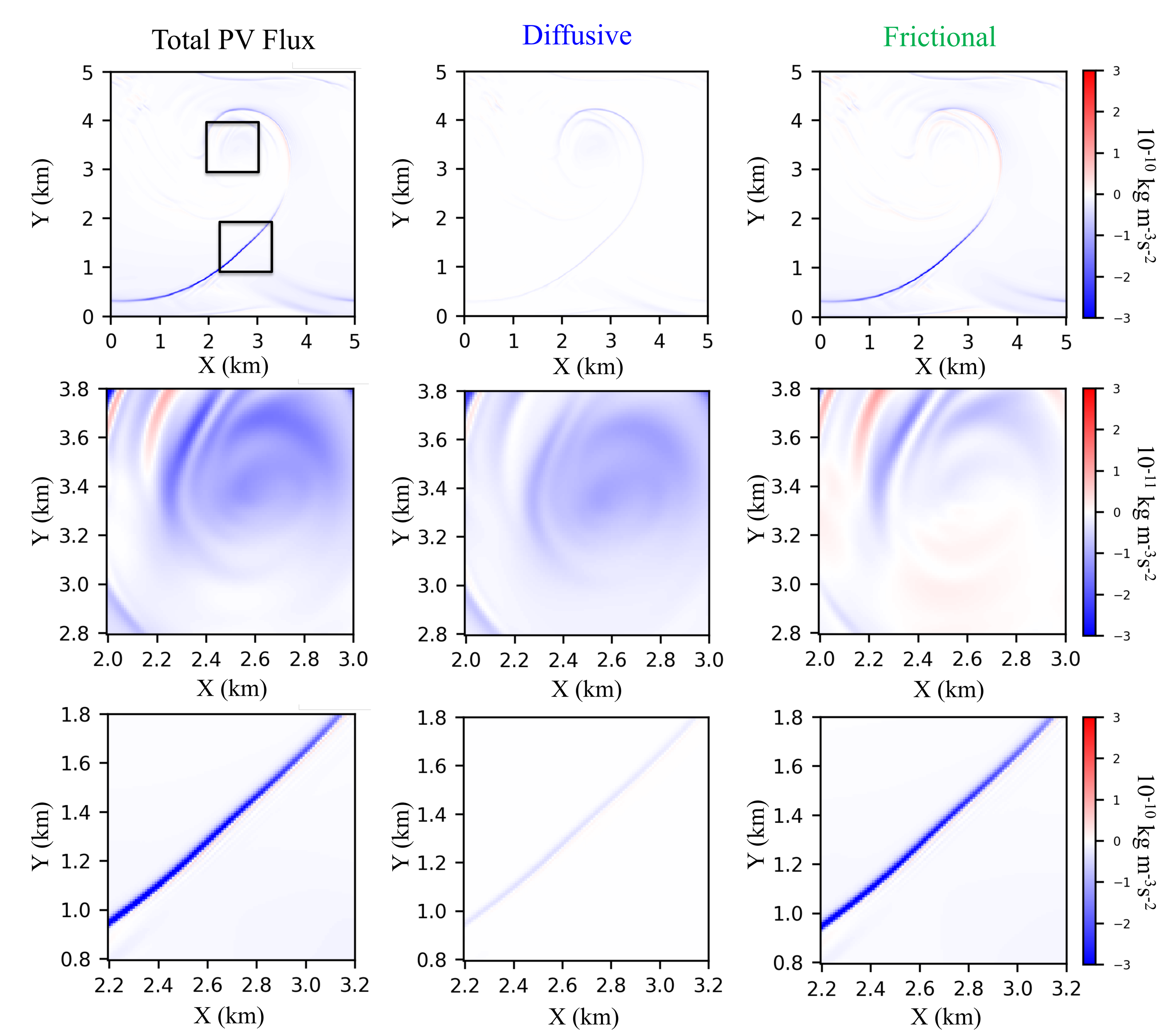


Wind Stress Curl & Surface Current Vorticity (Scheme B)



PV Flux at Surface (Scheme B – Scheme A)

$$\vec{J} = \vec{\omega}\frac{D\sigma}{Dt} + \vec{F}\times\nabla\sigma$$ (Marshall et al. 2001)



References

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- Chelton, Dudley B., Schlax, M. G., and R. M. Samelson, (2007). Summertime coupling between sea surface temperature and wind stress in the California Current System. *J. Phys. Oceanogr.*, 37, 495–517, https://doi.org/10.1175/JPO3025.1.
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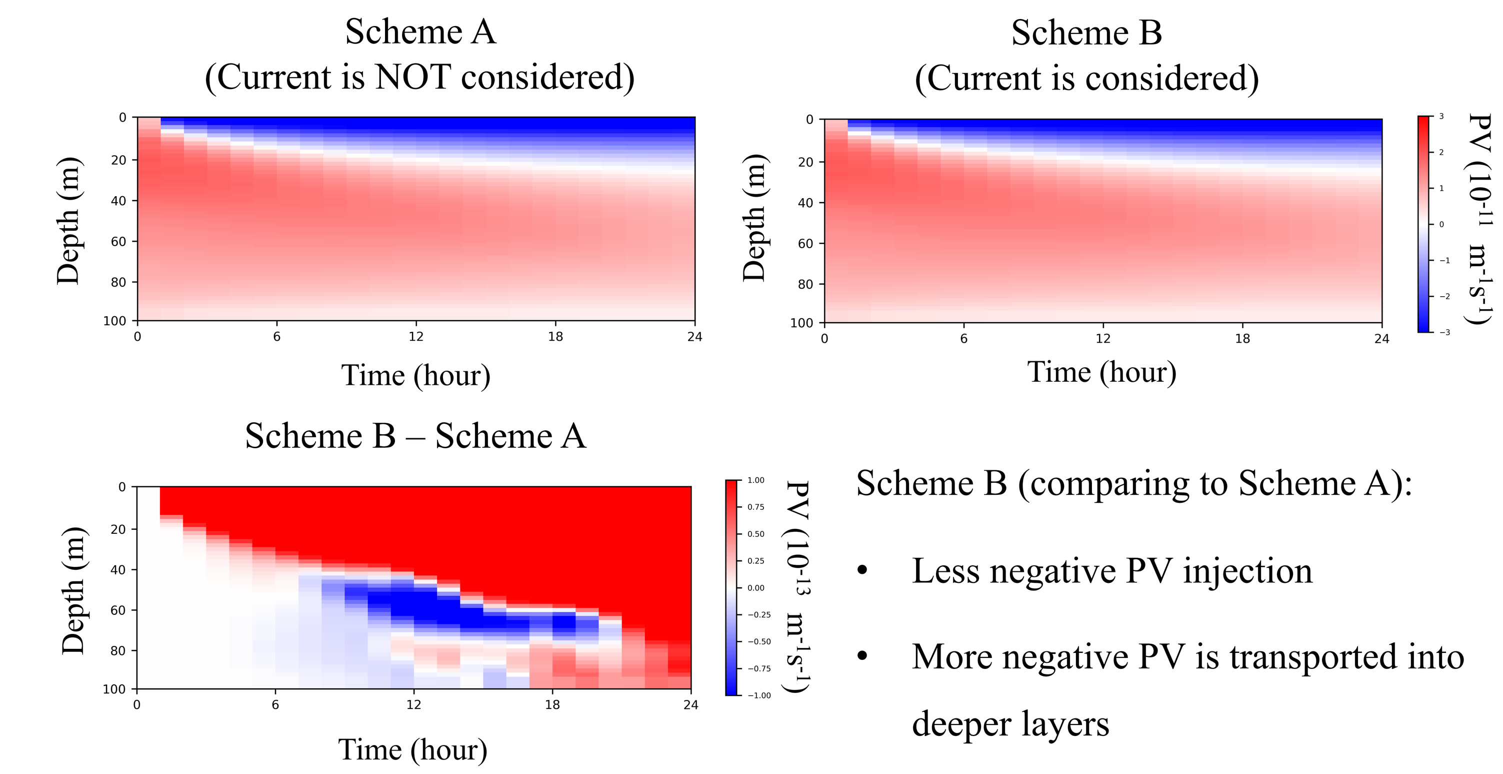
- Stern, W., (1965). Interaction of a uniform wind stress with a geostrophic vortex. *Deep-Sea Res.*, 12, 355-367.

Hovmöller Diagrams of Horizontally Averaged PV

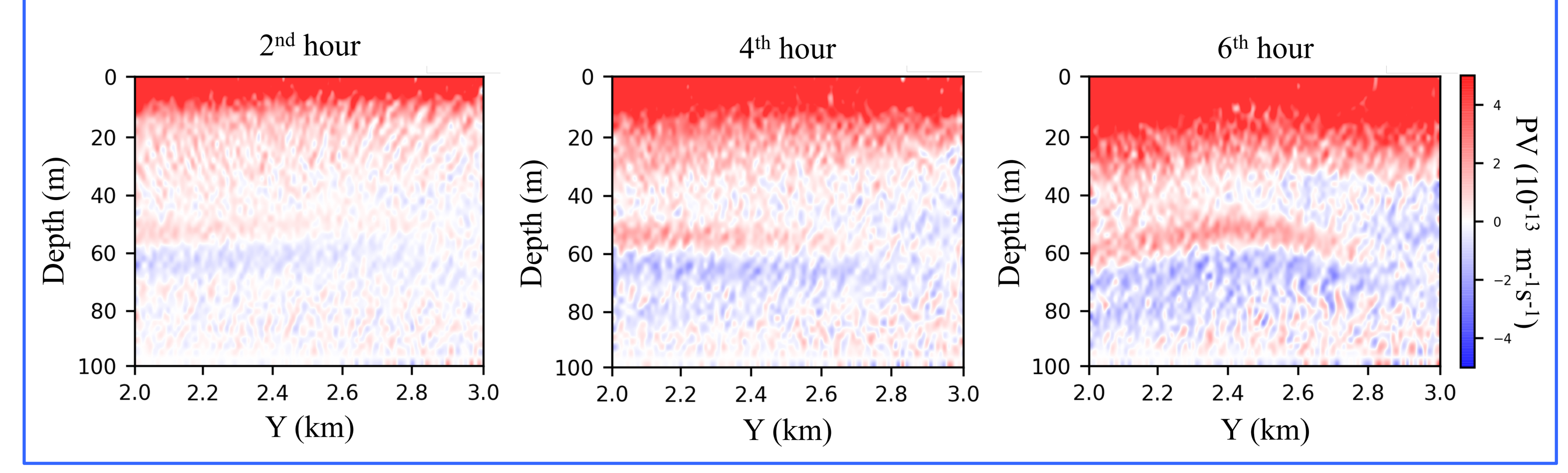
- Comparison between 24-hour experiments using Scheme A and Scheme B



Scheme B (comparing to Scheme A):

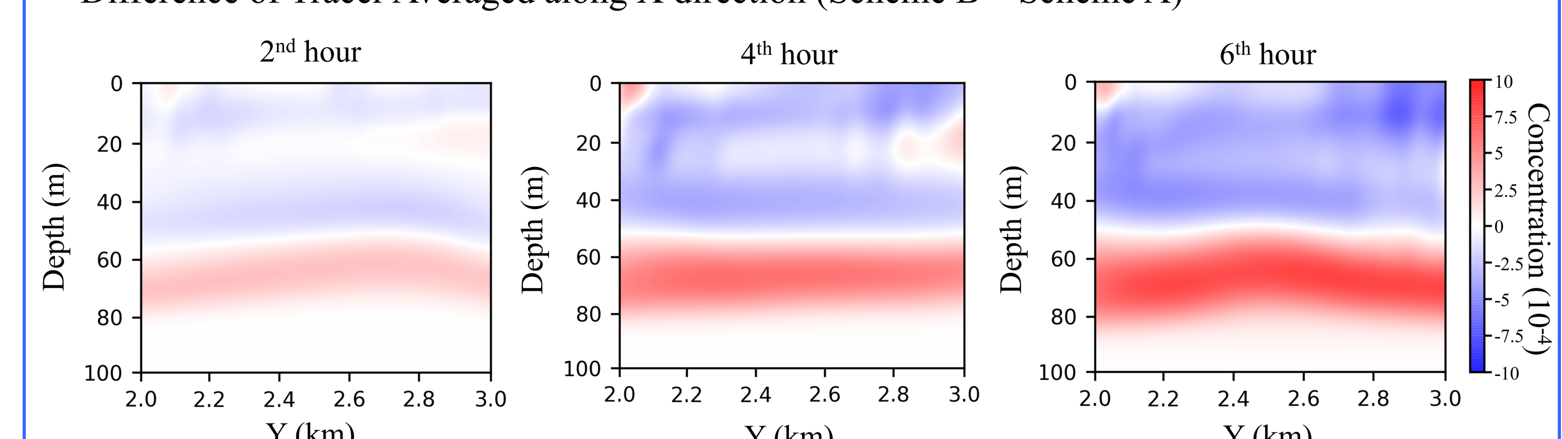
- Less negative PV injection
- More negative PV is transported into deeper layers

Difference of PV Averaged along X direction (Scheme B – A)

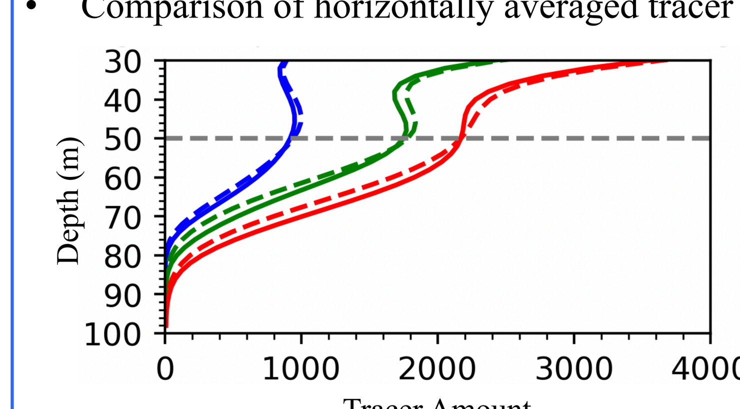


Vertical Transport of Passive Tracer from Surface

- Difference of Tracer Averaged along X direction (Scheme B – Scheme A)



- Comparison of horizontally averaged tracer profiles at 2nd, 4th, 6th hour (dashed: A; solid: B).



In Scheme B (compare to Scheme A):

- More passive tracer is transported into layers beneath 50 m depth.

- Table: Quantitative assessment of passive tracer transported into layers beneath 50 m depth.

Time (hour)	Current (B)	No Current (A)	Current – No Current (B-A)	Percentage Increase (%)
1	4087	3991	96	2.4
2	8411	7919	492	6.2
3	12088	11062	1026	9.3
4	16592	15125	1467	9.7
5	20841	18932	1909	10.1
6	24741	22402	2339	10.4